

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554**

In the Matter of)	
Waiver of Part 25 Licensing Requirements for)	IB Docket No. 17-16
Receive-Only Earth Stations Operating with the)	
Galileo Radionavigation-Satellite Service)	

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SUMMARY

Trimble Inc. and Deere & Company (together, the “Joint Commenters”) urge the Commission to promptly grant the waiver of its licensing requirements to allow non-federal receive only earth stations within the U.S. to operate with signals of the Galileo Radionavigation-Satellite Service System (“Galileo”).

First, grant of the waiver will provide significant benefits to the American public by augmenting the Global Positioning System (“GPS”) system and enabling enhanced availability, accuracy, integrity, and continuity. These benefits can be seamlessly achieved because GPS and Galileo are compatible and are interoperable at both the system and user levels. Promoting reception of Galileo signals supports both domestic policy goals and international agreements and strengthens the Global Navigation Satellite System (“GNSS”) in general and GPS in particular on a worldwide basis.

Second, the Commission should grant the waiver for all of the signals identified in the Public Notice. Receivers using Galileo signals will create no risk of additional interference to GPS, as Galileo signals have similar power levels as GPS signals and do not affect the vulnerability of receivers in adjacent or nearby bands. The Commission should permit reception of the Galileo E1 signal below 1559 MHz so long as the Galileo E1 signal and Public Regulated Service signals are compatible and interoperable with GPS and the Galileo E1 Open Service signal remains available.

Finally, while the Commission should grant the current waiver request using the processes in place, it and the National Telecommunications and Information Administration should separately and in the future re-examine the way that it considers whether to permit reception of non-U.S. GNSS signals. The current method is complex and lengthy. Similarly, the

Commission should separately re-evaluate the current treatment of GNSS receivers as satellite receivers under its rules.

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COMMENTS OF TRIMBLE INC. AND DEERE & COMPANY

Trimble Inc. (“Trimble”) and Deere & Company (“Deere,” and together with Trimble, the “Joint Commenters”) hereby respond to the Commission’s Public Notice seeking comment on the request submitted by the National Telecommunications and Information Administration (“NTIA”), on behalf of the European Commission (“EC”), for waiver of the Commission’s licensing requirements to permit non-federal receive-only earth stations within the United States to operate with signals of the Galileo Radionavigation-Satellite Service (“RNSS”) system (“Galileo”).^{1/} The Joint Commenters support expeditious grant of the requested waiver, which will benefit U.S. businesses and consumers and is consistent with domestic policies and international agreements.^{2/} It also urges the Commission to streamline the process of permitting reception of transmissions from additional Global Navigation Satellite System (“GNSS”) systems in the future.

I. INTRODUCTION

Founded in 1978, Trimble is a leading provider of advanced positioning solutions using Global Positioning System (“GPS”), GNSS, their augmentations, laser, optical, and inertial

^{1/} *FCC Seeks Comment on Waiver of Part 25 Licensing Requirement for Receive-Only Earth Stations Operating with the Galileo Radionavigation-Satellite Service*, Public Notice, IB Docket No. 17-16, DA 17-18 (rel. Jan. 6, 2017) (“*Galileo Public Notice*”).

^{2/} *See* the attached Annex for a partial list of domestic policies and international agreements with which the Commission’s action would be consistent.

technologies. Trimble integrates such technologies with application software, wireless communications, and services to provide complete commercial solutions and to make field and mobile workers in businesses and government significantly more productive. Its integrated solutions not only allow customers to collect, manage, and analyze complex information faster and easier, but also makes them more efficient, effective, and profitable. Trimble's products are distributed in over 100 countries around the world, and it has offices in over 35 countries, along with a highly capable network of dealers and distribution partners. Trimble's portfolio includes over 1,200 unique patents and serves as the basis for the broadest array of offerings in the industry.

Deere is a world leader in the manufacture of agricultural, construction, and forestry machinery, diesel engines, and other machinery equipment. It provides agricultural and other equipment and services to customers that cultivate, harvest, transform, enrich and build upon the land to meet the world's dramatically increasing need for food. Deere has delivered innovative equipment since 1837, and today, is pioneering state-of-the-art data and information solutions designed to greatly enhance productivity and environmental safety. Deere incorporates its high precision location technology in agricultural, construction and other equipment, which enables equipment operators to pinpoint their location to within 2-10 centimeters. In the agricultural sector, this high precision system enables growers to manage land, water, seed, fertilizer, pesticides and labor resources to significantly minimize costs and waste, greatly increase efficiency and crop yield, and responsibly manage important environmental concerns.

GPS services and GPS-enabled technology are deeply and permanently embedded in the U.S. economy and are an essential and key part of virtually every American's daily life. A Boston Consulting Group study commissioned by Google found that in 2011 alone, the U.S.

geospatial industry generated approximately \$73 billion in revenues.^{3/} Moreover, geospatial services deliver efficiency gains in the rest of the U.S. economy, driving \$1.6 trillion in revenue and \$1.4 trillion of cost savings, which is 15 to 20 times the size of the geospatial services industry itself.^{4/} Another more recent review produced a similar estimate, placing the annual economic value of GPS benefits in the U.S. at \$68.7 billion, which was more than likely an underestimate due to data limitations.^{5/} In fact, GPS is now so ubiquitous in the U.S. that the value of GPS has become as difficult to assess as the value of utilities like telephones and electricity.^{6/} Finally, GPS is also essential to the rapidly burgeoning unmanned aerial vehicle industry, which is estimated to produce economic benefits of over \$82.1 billion from 2015 to 2025 and 100,000 new jobs in the first three years.^{7/}

Pursuant to the Commission's rules, non-federal receive-only earth stations in the U.S. operating with non-U.S. licensed RNSS systems must obtain a license.^{8/} The Commission may grant waiver of this requirement if it is in the public interest, is consistent with its guidelines and international trade and treaty obligations, is limited to RNSS services, and is compatible with federal operations in the RNSS bands.^{9/} This standard supports a waiver for devices used in the

^{3/} See *Putting the U.S. Geospatial Services Industry On the Map 2*, THE BOSTON CONSULTING GROUP 2 (July 2013), <http://www.valueoftheweb.com/> ("Boston Consulting Study").

^{4/} Boston Consulting Study at 3.

^{5/} Irv Leveson, *The Economic Value of GPS: Preliminary Assessment*, 8, 15, GPS.GOV (June 11, 2015), <http://www.gps.gov/governance/advisory/meetings/2015-06/leveson.pdf>.

^{6/} GREG MILNER, PINPOINT 100-01 (W.W. Norton & Co. 2016).

^{7/} Darryl Jenkins & Bijan Vasigh, *The Economic Impact of Unmanned Aircraft Systems Integration in the United States 2*, ASS'N OF UNMANNED VEHICLE SYS. INT'L (Mar. 2013), http://robohub.org/_uploads/AUVSI_New_Economic_Report_2013_Full.pdf.

^{8/} 47 CFR § 25.131(j)(1).

^{9/} See *National Telecommunications and Information Administration Provides Information Concerning Executive Branch Recommendations for Waiver of Part 25 Rules Concerning Licensing of Receive-Only Earth Stations Operating with Non-U.S. Radionavigation Satellites*, Public Notice, 26 FCC Rcd 3867 (IB Mar. 15, 2011) ("RNSS Public Notice"); see discussion *infra* Section IV(A).

U.S. to receive signals from Galileo. As noted below, grant of the waiver will significantly benefit the American public by improving and strengthening GPS service availability. Additionally, grant of the waiver is consistent with U.S. space policy and with international agreements between the U.S. and Europe. Finally, grant of the waiver will promote a seamless GNSS service for civil and commercial users worldwide, which will enhance U.S. leadership in space-related technology.

II. GRANT OF THE WAIVER IS IN THE PUBLIC INTEREST

A. Additional Access to RNSS Signals Will Benefit the American Public.

1. *Receiver Access to Additional Constellations Can Augment GPS Services.*

Access to Galileo will benefit GNSS users in the U.S. by enabling safer and more efficient transportation by land, sea, and air; improving agriculture and food security; reducing risks of disaster; enabling emergency response, including E-911; simplifying survey and mapping, construction, and scientific research; and synchronizing financial operations, power grid, and other critical infrastructure. In particular, access to both Galileo and GPS signals in a single user device can increase service availability, accuracy, integrity, and continuity—key attributes of a successful RNSS offering.

Better Accuracy. With respect to accuracy, the European Global Navigation Satellite Systems Agency (“GSA”) observed that:

Recent tests conducted by Rx Networks and the GSA confirm that Galileo provides real added value to citizens using Location Based Services (LBS). When used in addition to GPS and/or GLONASS, Galileo proved to significantly improve accuracy in challenging environments, including urban canyons and indoors. . . . Specifically, the results showed that adding Galileo on top of GPS and GLONASS improves the accuracy of location fixes when indoors or in urban canyons. This improved accuracy will have a profound

impact across numerous sectors, including critical situations like [E-911 and/or] E-112 emergency calls.^{10/}

Improved Availability. Similarly, tests have shown that:

Using a combined GPS and Galileo system is advantageous in all of the situations [studied]. Most importantly, using two systems provides sufficient availability for navigation in extreme masking environments, where navigation with GPS is currently very difficult.^{11/}

Increased Reliability, Higher Integrity. Finally, studies have indicated that:

Clear benefit is obtained when combining GPS and Galileo; this benefit is very remarkable in urban environments, allowing users to see more than four satellites in view. Significant improvements are also achieved in terms of accuracy, availability and continuity. But the biggest improvement is in the area of integrity, where RAIM [Receiver Autonomous Integrity Monitoring] availability increases significantly even for cases with four or five satellite failures.^{12/}

The difference between GPS-only and GPS and Galileo receivers begins after the signal is down-converted to baseband and sampled into the digital domain. From there, the functional differences are in the demodulation portion of the digital signal processing, and in the software that converts the fundamental raw phase measurements into position and time solutions. After the signals are demodulated, the receiver establishes the raw phase measurements, which include the code-phase pseudoranges, and in some cases, carrier-phase measurements. In addition to the raw phase measurements, essential data about each GNSS constellation, known as the almanac and ephemerides, is demodulated at a relatively low bit rate from each of the satellite signals. The almanac, ephemerides, and raw phase measurements comprise all the essential information the receiver needs to calculate a position and time solution.

^{10/} *The Results Are In: Galileo Increases the Accuracy of Location Based Services*, EUR. GLOBAL NAVIGATION SATELLITE SYS. AGENCY, <https://www.gsa.europa.eu/news/results-are-galileo-increases-accuracy-location-based-services> (last updated June 11, 2014).

^{11/} KYLE O'KEEFE, AVAILABILITY AND RELIABILITY ADVANTAGES OF GPS/GALILEO INTEGRATION 2103 (2001).

^{12/} MIGUEL M. ROMAY MERINO, ET AL., AN INTEGRATED GNSS CONCEPT, GALILEO & GPS, BENEFITS IN TERMS OF ACCURACY, INTEGRITY, AVAILABILITY AND CONTINUITY 2124 (2001).

The availability of raw phase measurements, almanacs, and ephemerides from satellites in two or more GNSS constellations within a single GNSS receiver is the basis for increased accuracy and availability. A “minimal” GNSS receiver solution requires four satellite signals to generate a three-dimensional solution, by solving three spatial dimensions and time. The quality of the position solution depends on the geometric configuration of the satellite signals (*i.e.* the dilution of precision or “DOP”) and the quality of the signal phase measurements. A GNSS receiver taking measurements from satellites in two or more GNSS constellations will always have a better geometric configuration (measured as a lower DOP value) and will have more satellites in view for any given sky-view condition. The signals in excess of four form an over-determined system, which not only improves accuracy, but also provides the mechanism for quantifying the integrity of the solution. GNSS integrity methods generally use statistical analysis of over-determined solutions to assess reliability. The receiver algorithms that measure the solution integrity are known as Receiver Autonomous Integrity Monitoring (“RAIM”). The availability of raw phase measurements from GPS and Galileo combined improves accuracy, availability, continuity and integrity. The availability of almanac and ephemerides from satellites in two independently managed constellations provides a measure of redundancy against partial or catastrophic failure of either system.

Therefore, co-processing of both Galileo and GPS signals in certain types of receivers, possible with modern processors that have sufficient bandwidth, increases availability, continuity, integrity, and accuracy.

2. *Galileo Will Be Interoperable with GPS and RF Compatible with U.S. Government Systems and Equipment Already in Use and Operating in the RNSS Bands.*

The 2004 U.S. Space-Based Positioning, Navigation, and Timing Policy (“U.S. Space-Based PNT Policy”), the 2010 National Space Policy, and Congress encourage compatibility and interoperability with GPS, which is pursued through bilateral and multilateral cooperation.^{13/} Grant of the waiver request will support these important U.S. policy goals.

a. *Compatibility.* According to the U.S. Space-Based PNT Policy, “[c]ompatible’ refers to the ability of U.S. and non-U.S. space-based positioning, navigation, and timing services to be used separately or together without interfering with each individual service or signal to ensure radio frequency compatibility [and] spectral separation between M-code and other signals.”^{14/} In other words, compatibility is the ability of U.S. and non-U.S. space-based positioning, navigation, and timing (“PNT”) services to be used separately or together without interfering with each individual service or signal. Compatibility between multiple GNSS systems is accomplished in a variety of ways.

One way compatibility is accomplished is through the different geometries of the orbits of the various constellations and the physical separation of the space-based transmitters. A second way is use of different Pseudo Random Number (“PRN”) codes used to implement the CDMA channels. These PRN codes are carefully selected within each GNSS (GPS and Galileo independently) to cause minimal cross-correlation and between the different constellations to

^{13/} 10 U.S.C. § 2281 (2016); *U.S. Space-Based Positioning, Navigation, and Timing Policy*, GPS.GOV (Dec. 15, 2004) (“*U.S. Space-Based PNT Policy*”), <http://www.gps.gov/policy/docs/2004/>; *National Space Policy of the United States of America* (June 2010), https://obamawhitehouse.archives.gov/sites/default/files/national_space_policy_6-28-10.pdf.

^{14/} David A. Turner, *GNSS Interoperability Through International Cooperation*, GPS.GOV (May 19, 2011), <http://www.gps.gov/multimedia/presentations/2011/05/CSNC/turner2.pdf>.

minimize the co-channel interference between systems. As discussed in ITU-R Recommendation ITU-R M.1787-2,^{15/} these codes:

- Provide good multiple access properties among different satellites, since all satellites transmit on the same carrier frequencies and are differentiated from one another only by the unique PRN codes they use; and
- Their correlation properties allow precision measurement of time of arrival and rejection of multipath and interference signals.

ITU-R Recommendation ITU-R M.1831 provides methods to calculate the effect of one GNSS system's codes on another, and to assure inter-system impact is minimized.^{16/}

A third way is through efficient use of allocated RNSS spectrum. When a frequency resource is shared using CDMA techniques, spectrum is used most efficiently when all received signals are of the same, or nearly the same, signal power. A further review of ITU-R M.1787-2 shows that all of these GNSS systems have similar orbits, similar altitudes, and similar output powers, among other things, all of which lead to a similar received signal level when on or near the Earth's surface. Because all of the transmitters are nearly the same distance from the receivers, there is no near/far problem that plagues other CDMA systems.

b. Interoperability. As set forth in the U.S. Space-Based PNT Policy, “[i]nteroperable” refers to the ability of civil U.S. and non-U.S. space-based positioning, navigation, and timing services to be used together to provide better capabilities at the user level than would be achieved by relying solely on one service or signal.”^{17/} Interoperability is one step

^{15/} Recommendation ITU-R M.1787-2: *Description of Systems and Networks in the Radionavigation-Satellite Service (Space-to-Earth and space-to-space) and Technical Characteristics of Transmitting Space Stations Operating in the Bands 1164-1215 MHz, 1215-1300 MHz and 1559-1610 MHz*, INT’L TELECOMM. UNION (Sept. 2014), https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1787-2-201409-I!!PDF-E.pdf.

^{16/} Recommendation ITU-R M.1831-1: *A Coordination Methodology for Radionavigation-Satellite Service Inter-System Interference Estimation*, INT’L TELECOMM. UNION, (Sept. 2015), https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1831-1-201509-I!!PDF-E.pdf.

^{17/} U.S. Space-Based PNT Policy.

beyond mere compatibility between systems. The assessment of interoperability between GPS and Galileo is conducted at two levels, the overall system level and the user level. To use the systems together they must each produce virtually the same position and time fix when used independently.

Interoperability at the System Level. GNSS satellite orbital measurements are made by several geographically diverse reference sites. These sites are surveyed to a reference frame, which will, in turn, control the position that a user will get from a receiver. GPS reference sites are surveyed to the WGS-84 reference frame, and Galileo uses the Galileo Terrestrial Reference Frame. Since these two frames agree within 3 cm of each other, the difference between position fixes from the two GNSS systems will be small enough that a combined solution with improved accuracy is possible.

Both GPS and Galileo systems maintain arrays of highly accurate atomic clocks. The two clock arrays are independent, but they are both very accurate, stable over time, and maintained with respect to a common time reference such that they are never more than a few nanoseconds apart. This small time difference is measured and is known as the GPS to Galileo Time Offset (“GGTO”). The GGTO is distributed via the navigation messages on GPS and Galileo satellites to allow interoperable timing measurements and to improve the position interoperability.

Interoperability at the User Level. At the user level, interoperability starts at the antenna. Both systems have signals in approximately the same span of frequencies and have the same polarization, Right Hand Circular. This permits a user to collect all of the GPS and Galileo signals with a single antenna. If multiple antennas were required, then interoperability would be

hindered due to the inconvenience and the inaccuracies associated with multiple receive locations.

The next user level of interoperability occurs at the Radio Frequency (“RF”) front end of the receiver, which is responsible for frequency conversion, amplification, filtering, and analog to digital conversion (“A/D”). The Galileo E1 signal (1559-1591 MHz), corresponds almost exactly with the GPS L1 signal in frequency and bandwidth, hence the RF section of any GPS receiver will be interoperable with the Galileo E1 signal. Likewise, the Galileo E5a signal (1164-1188 MHz) is coincident with the GPS L5 signal in frequency and bandwidth, ensuring RF interoperability for all GPS L5 capable receivers.

Assessing interoperability for the Galileo E5b signal (1195-1219 MHz), is more complex because it does not correspond to a GPS signal in this frequency range and because there are two prevalent GPS RF architectures. The first such architecture is known as channelized because it has a fairly independent RF section for each GNSS frequency band. A channelized GPS receiver will not be interoperable with the Galileo E5b signal. The other architecture is known as wideband because it has two RF sections—one for the lower frequency bands used for the GPS L2 and L5 signals, and the other for the higher frequency bands used for the GPS L1 and GLONASS G1 signals. A wideband receiver will handle the range of L5 to L2 signals, 1164-1239 MHz, as a continuum, and that range encompasses the E5b signal, so such receivers will have RF interoperability with Galileo.

The Galileo E6 signal operates in the radiofrequency band 1260-1300 MHz.^{18/} The Galileo E6 signal does not correspond to any GPS signal and therefore, the E6 signal introduces

^{18/} The Joint Commenters support grant of the waiver for reception of all Galileo signals on which comment is sought in the *Galileo Public Notice*. The Joint Commenters understand that a “commercial service” is additionally intended for the Galileo E6 band, and is under development. Grant of a waiver for the reception of the Galileo E6 signal by the Commission would not preclude any necessary future review

no interoperability issues. The E6 signal enables various sophisticated positioning techniques, and one design goal of the E6 signal is to reduce detrimental effects of multipath, potentially enabling receivers that utilize the signal to achieve high-precision accuracy in more situations than those relying only on Galileo E1 and E5 signals. GNSS receivers designed with E6 capability are fully interoperable with GPS.

The digital section of the receiver takes the data from the A/D converters, measures the timing of the signal's code and phase, and then uses those timing measurements to calculate position. Both GPS and Galileo use Direct Sequence Spread Spectrum Code Division Multiple Access ("CDMA") modulation schemes to allow multiple satellites to transmit on the same frequency and to transfer timing from the satellite to the user. To receive the navigation signal, the user must generate a local copy of the code for that signal, and that code is unique for each GPS and Galileo satellite. Some GPS receivers use hardwired logic circuitry to generate these local codes, while others use code generators that may be configured by the software. The GPS receivers with hardwired code generators are not interoperable with Galileo, while those with configurable generators can be made interoperable with a software update. Chipsets capable of demodulating Galileo signals have been in use for more than ten years.

B. U.S. Recognition of Galileo Would Promote the U.S. Space-Based PNT Policy on Back-Up Capabilities.

The U.S. Space-Based PNT Policy encourages the U.S. to "improve and maintain . . . backup capabilities to meet growing national, homeland, and economic security requirements, for civil requirements, and to meet commercial and scientific demands" of its PNT system.^{19/} GPS is the world's leading PNT service. It provides primary PNT solutions worldwide with

of market access and other conditions of the Galileo commercial service in the U.S. by other U.S. governmental entities that may pertain to trade and other considerations in international negotiation.

^{19/} *U.S. Space-Based PNT Policy.*

unrivaled accuracy, integrity, continuity, and availability driven by broad user adoption and investment in GPS innovation. Grant of the waiver request will promote the policy by augmenting GPS, which will, in turn, strengthen GPS's overall effectiveness and allow it to continue providing integral services. Specifically, the waiver will permit Galileo to serve as a "reliable alternative" to facilitate the continued accessibility of GNSS services in the event of disruption.^{20/} Galileo is an internationally-accepted GNSS system and, as discussed above, is interoperable with GPS. In comparison to other GNSS systems, Galileo comes closest to GPS in terms of capabilities, performance, and user acceptance.^{21/} Europe has strategically positioned Galileo to enhance GPS and the other GNSS systems available worldwide.^{22/} Encouraging Galileo as a recognized and vital component of GNSS would eliminate the risk of a single point of failure and, at the same time, would meet the diverse needs of GNSS users.^{23/}

C. U.S. Recognition of Galileo and Other GNSS Systems Is Also Consistent with International Agreements and Will Facilitate International Acceptance of GPS.

In 2004, the U.S., along with the EC and the European Union member states, entered the Agreement on the Promotion, Provision, and Use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications.^{24/} The fundamental purpose of this agreement was to coordinate efforts regarding the "promotion, provision, and use of" GPS and Galileo GNSS

^{20/} See *U.S. Spaced-Based PNT Policy*.

^{21/} See *Galileo Is The European Global Satellite-Based Navigation System*, EUR. GLOBAL NAVIGATION SATELLITE SYS. AGENCY, <https://www.gsa.europa.eu/european-gnss/galileo/galileo-european-global-satellite-based-navigation-system> (last visited Feb. 14, 2017).

^{22/} *Id.*

^{23/} See *GPS and Galileo... Progress Through Partnership*, GPS.GOV, <http://www.gps.gov/policy/cooperation/europe/2007/gps-galileo-fact-sheet.pdf> (last visited Feb. 14, 2017).

^{24/} *Agreement on the Promotion, Provision, and Use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications*, June 26, 2004, <http://www.gps.gov/policy/cooperation/europe/2004/gps-galileo-agreement.pdf>.

systems.^{25/} Recognizing Galileo will help achieve this key objective. Moreover, the U.S. Space-Based PNT Policy calls for the U.S. to “promote U.S. technological leadership in applications involving space-based positioning, navigation and timing services.”^{26/} Just as permitting Galileo reception in the U.S. would be consistent with the GPS/Galileo agreement, Commission action will help promote reciprocal acceptance of GPS in Europe, further strengthening the position of GPS worldwide.

III. THE COMMISSION SHOULD AUTHORIZE RECEPTION OF ALL IDENTIFIED SIGNALS

A. Use of All Signals in the Public Notice Will Enhance the Public Interest Benefits by Creating a More Robust GNSS Ecosystem.

The Commission seeks comment on whether reception of each of Galileo’s E1, E5, and E6 signals would improve service availability, accuracy, and reliability, and whether the signals will improve GPS resiliency.^{27/} As discussed above, grant of the waiver will significantly improve GPS and GNSS by providing a more robust system for land, air, and sea navigation, emergency response, and scientific research, among others benefits. Those benefits are recognized by allowing receivers to access signals from all available RNSS satellites. The public safety and security benefits that would be conferred by grant of the waiver are significant.

^{25/} *Id.*

^{26/} *U.S. Space-Based PNT Policy.*

^{27/} *Galileo Public Notice* at 11-12.

B. Multi-Service RNSS Receivers, Like Devices with Galileo Frequencies, Require No More Protection Than GPS-Only Receivers, and Galileo Signals Raise No New Interference Concerns.

The Commission seeks comment on whether the Galileo signals raise interference concerns with respect to non-federal receiver operations.^{28/} While devices with Galileo frequencies may use slightly different RNSS frequencies, meaning that they may have different potential for interference from other devices, the interference profile of those devices will be the same as GPS-only devices using the GPS L1, L2, and L5 signals. As noted in the discussion on interoperability, the ability to receive Galileo E1 and E5 signals will already be present in receivers that use GPS L1 and L5 signals. Also, the received Galileo signals will be close in power level to GPS signals, so the signal to noise and signal to interference ratios will likewise be close.^{29/}

The Commission asks whether devices with the capability of receiving signals from Galileo will be more resistant to interference than GPS-only receivers.^{30/} There is no impact on resiliency as the Commission has defined it. What interferes with GPS-only receivers will also interfere with both Galileo-only receivers and with combined GPS/Galileo receivers. The access to Galileo signals on a GNSS receiver increases availability and provides other enhancements, but it does not otherwise affirmatively or negatively affect vulnerability of GNSS receivers to interference from adjacent/nearby band operations. Granting the waiver would have no positive effect on the ability of a combined GPS/Galileo receiver (or any other GNSS receiver) to operate

^{28/} *Id.* at 7.

^{29/} *Recommendation ITU-R M.1787-2: Description of Systems and Networks in the Radionavigation-Satellite Service (Space-to-Earth and Space-to-Space) and Technical Characteristics of Transmitting Space Stations Operating in the Bands 1164-1215 MHz, 1215-1300 MHz and 1559-1610 MHz*, INT'L TELECOMM. UNION (Aug. 2014), http://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.1787-2-201409-I!!PDF-E.pdf.

^{30/} *Galileo Public Notice* at 10.

in the face of interference from other radio devices. In the U.S., the services allocated for the 1240-1300 MHz band are aeronautical radionavigation, amateur, earth exploration satellite system, and space research. Because Galileo E6 utilizes the 1260-1300 MHz portion of this allocation, it is not the exclusive user of this spectrum.

C. The Commission Should Extend the Waiver to Operations with the Galileo E5 and E6 Signals.

The Commission seeks comment on whether the waiver will have an impact on non-federal operations in the 1164-1215 MHz, 1215-1240 MHz, and 1240-1300 MHz bands.^{31/} Galileo will transmit E5 signals over the 1164-1219 MHz band, and E6 signals over the 1260-1300 MHz band. These signals provide enhancements to Galileo and GNSS operations. To the limited extent that there are non-federal operations in or near the Galileo E5 and E6 frequency bands, the risk of interference to these operations is very low. As the Commission pointed out in the *Galileo Public Notice*, NTIA found that RF compatibility between non-federal and federal operations has been achieved in these bands or adjacent bands.^{32/}

D. The Commission Should Permit Conditioned Reception of Galileo's E1 Signal Below 1559 MHz.

The Commission notes that the Galileo Public Regulated Service E1 signal, with a 40 MHz bandwidth, would extend below the lower boundary of the RNSS band at 1559-1610 MHz into a band allocated for mobile-satellite service downlinks.^{33/} The Commission asks whether it should waive on its own motion relevant provisions of the U.S. Table of Frequency Allocations in Section 2.106 of its rules to permit reception of these Galileo signals.^{34/} The Joint

^{31/} *Id.* at 11.

^{32/} *See, e.g., id.*

^{33/} *Id.* at 3-4.

^{34/} *Id.* at 4, 6.

Commenters support such a waiver as necessary, based on the Joint Commenter's understanding: 1) that the Galileo E1 Open Service and Public Regulated Service signals will be compatible and interoperable with GPS as discussed above; and 2) that the Galileo E1 Open Service signal will always be available.

IV. THE COMMISSION SHOULD PROMOTE A SEAMLESS GNSS SERVICE

A. The Process for Obtaining a Waiver of the Commission's Rules for New Non-U.S. GNSS Signals Is Unnecessarily Complex.

As stated in the *Galileo Public Notice*, the current process for obtaining waiver is complex. In March 2011, the Commission released a Public Notice outlining the criteria that NTIA must consider when determining whether to recommend that the Commission grant a waiver.³⁵ Before the Commission can initiate its process, NTIA must first recommend that the Commission grant a waiver of its licensing requirements. NTIA is required to consider whether “(1) granting the waiver is in the public interest; (2) the system complies with the United Nation's Space Debris Mitigation guidelines; (3) the grant of the waiver is consistent with U.S. International trade and other treaty obligations; (4) the waiver request is limited to the receive-only Radionavigation-Satellite Service (RNSS) (which includes positioning) and standard time and frequency satellite services; and (5) operation of the RNSS signals offered by the foreign Global Navigation Satellite System (GNSS) has been found compatible with U.S. government systems operating in the specified RNSS frequency bands.”^{36/} Once NTIA completes this analysis, it can provide its recommendation to the Commission.

The timeframe between the EC's request and ultimate FCC action was therefore lengthy. The EC first requested waiver in October 2013—over three years prior to the start of the

^{35/} *RNSS Public Notice*.

^{36/} *Galileo Public Notice* at 2, note 6.

Commission's comment period regarding grant of the waiver.^{37/} While the Commission should promptly grant the current request using the process in place, NTIA and the Commission should separately evaluate whether in the future, a more streamlined approval process would both speed the approval of acceptable non-U.S. GNSS satellite signals.

B. The Commission's Licensing Waiver Rules for New Non-U.S. GNSS Signals Are Outdated with Respect to Modern GNSS Technologies.

Moreover, as written, the Commission's rules do not contemplate GPS technology and GPS-enabled devices. The Commission's current foreign licensing process is, therefore, outdated and does not reflect evolving technologies and infrastructure.^{38/} The rules were never intended to capture ubiquitous GNSS devices, such as handheld GNSS receivers that can connect to mobile phones and tablets, allowing users to instantaneously receive positioning information, lower power chips readily found in consumer devices, and emerging autonomous devices.^{39/} Instead, the rules were designed for traditional, large, and stationary earth stations, which only constitute a relatively small subset of the equipment in use today.

The Commission's rules also do not recognize the current commercial reality of GPS and GNSS. GNSS devices are intended to provide coverage worldwide with other GNSS systems, not just within certain countries or geographical areas. GNSS enabled devices move freely across national borders, and many are designed for the global market, not just the U.S. To

^{37/} Letter from Paul Weissenberg, Deputy Director-General, European Commission, to Jonathan Margolis, Deputy Assistant Secretary, Bureau of Oceans and International Environmental and Scientific Affairs, U.S. Dep't of State (Oct. 23, 2013).

^{38/} See Comprehensive Review of Licensing and Operating Rules for Satellite Services, IB Docket No. 12-267, Second Report and Order, FCC 15-167 (2015) (Statement of Commissioner Ajit Pai) (discussing how the Commission's Part 25 rules are outdated, as initial drafting of the rules dates back to the 1960s).

^{39/} See, e.g., Liang Wang, et. al, *Smart Device-Supported BDS/GNSS Real-Time Kinematic Positioning for Sub-Meter-Level Accuracy in Urban Location-Based Services*, U.S. NAT'L LIBR. MED. (Dec. 21, 2016), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5191179/>.

ensure compatibility today, most devices sold in the U.S. with GNSS capabilities can receive GNSS signals from multiple constellations, not solely signals from GPS.^{40/} According to a study by the European Global Navigation Satellite Systems Agency, “almost 60 percent of all available receivers, chipset and modules support a minimum of two constellations. Of these, nearly 40 percent are Galileo compatible,” demonstrating multi-constellation capability.^{41/} Similarly, in the U.S., most devices are capable of supporting other international satellite constellations.^{42/} As the European GNSS Service Centre observed “a multi-constellation capability that includes Galileo is becoming a standard feature across all market segments.”^{43/} The Joint Commenters therefore respectfully submit that while the Galileo request should be promptly granted, it is time for the FCC, on a going-forward basis, to review its rules to better align the treatment of GPS devices operating with non-U.S. GNSS systems with current technological and market realities.

^{40/} The European Global Navigation Satellite Systems Agency estimates that “[b]y 2020, all new GNSS receivers be multi-constellation capable.” EUR. GLOBAL NAVIGATION SATELLITE SYS. AGENCY, GNSS USER TECHNOLOGY REPORT 8 (2016), https://www.gsa.europa.eu/system/files/reports/gnss_user_technology_report_webb.pdf.

^{41/} See GPS World Staff, *GSA: 40 Percent of GNSS Receivers Are Galileo-Ready*, GPS World (May 9, 2016), <http://gpsworld.com/40-of-gnss-receivers-are-galileo-ready/>; see also FAQs, EUR. GNSS SERV. CTR., <https://www.gsc-europa.eu/helpdesk/faqs> (last viewed Feb. 14, 2017).

^{42/} See, e.g., *R1 GNSS Receiver*, TRIMBLE, http://www.trimble.com/mappingGIS/R1-GNSS-Receiver.aspx?tab=Features_and_Benefits (last viewed Feb. 15, 2017).

^{43/} EUR. GNSS SERV. CTR., *supra* note 41.

C. Permitting Reception of Galileo Signals Will Help Enhance the U.S. Leadership in What Is Quickly Becoming an International GNSS PNT Service.

Not only will granting the EC's waiver request help further international operability of GNSS PNT service, it will reinforce the U.S. position as the world leader in GNSS technology and services. Widespread deployment of *all* GNSS systems will benefit GPS as PNT capabilities enhanced by multi-GNSS availability becomes broadly recognized.

V. CONCLUSION

Reception of signals from the Galileo constellation will provide significant public interest benefits and promote U.S. and international policies that support a robust global GNSS environment. Therefore, the Commission should promptly grant the waiver of its licensing requirements for non-federal receive only earth stations with respect to all signals identified in the *Galileo Public Notice*. Separately, the Commission should re-evaluate the process for permitting reception of non-U.S. GNSS signals and the U.S. regulatory treatment of devices capable of receiving GNSS signals.

Respectfully submitted,

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ANNEX

Following the announcement of the 2004 National Space-Based Positioning, Navigation, and Timing Policy and subsequent national policy statements from the President and Congress, the U.S. coordinated efforts regarding the promotion, provision, and use of Global Navigation Satellite Systems (“GNSS”). Included in this Annex is a partial list of, and excerpts from, domestic policies and international agreements with which a grant of waiver would be consistent.

U.S. POLICY STATEMENTS ON INTERNATIONAL SATELLITE NAVIGATION ISSUES

Inaugural Meeting of the International Committee on GNSS

“U.S. international efforts to promote compatibility and interoperability with the U.S. Global Positioning System are based on consistent national policy statements from the Executive and Legislative Branches.”^{1/}

“U.S. international efforts promote: common and open standards for worldwide interoperability; acceptance and use of GPS for peaceful civil, commercial and scientific applications; international cooperation in using GPS for peaceful purposes; safety and efficiency in transportation and strengthen and maintain national security.”^{2/}

International IGNSS Forum in 2007

“Positive results of over a decade of diplomatic efforts are beginning to be seen: New satellite constellations and regional augmentation systems, while independently owned and operated, are being designed to be compatible and interoperable; Coordination mechanisms are being created to promote interoperability, promote GNSS use, and ensure a level playing field in the global marketplace.”^{3/}

INTERNATIONAL COOPERATION: UNITED STATES AND EUROPE

U.S.-EU Agreement Establishing GPS-Galileo Cooperation

“In 2004, the U.S. and European Community signed an agreement on GPS-Galileo cooperation, recognizing the importance of compatibility and interoperability for all parties. The US and EU agreed to: spectrally separate signals for military, civilian, and public regulated services; implement a common, open, civil signal on both Galileo and GPS III, free of direct user fees;

^{1/} Ken Hodgkins, *U.S. International Efforts to Promote Compatibility and Interoperability with the Global Positioning System*, GPS.GOV. (Dec. 2005), <http://www.gps.gov/multimedia/presentations/2005/2005-12-ICG/>.

^{2/} *Id.*

^{3/} Ray Clore, *U.S. Diplomatic Efforts on International Satellite Navigation Issues*, GPS.GOV (Dec. 4, 2007), <http://www.gps.gov/multimedia/presentations/2007/2007-12-IGNSS/>.

establish Working Groups (WG) Compatibility and Interoperability [WGA]; Trade and Commercial Applications [WG-B]; WG-C, Next-Generation GNSS; WG-D, Security Issues.”^{4/}

Joint Statement on Galileo and GPS Signal Optimization, By the European Commission and the U.S.

“In June 2004, the European Commission and U.S. signed the Agreement on the Promotion, Provision and use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications on the compatibility and interoperability of the Galileo and GPS satellite navigation systems. A central element of the Agreement was a common baseline signal structure that could be optimized for greater performance. On 20-22 March 2006 in Stockholm, Sweden, the GPS-Galileo expert group on radio frequency compatibility and interoperability successfully produced a jointly-optimized common signal after 21 months of cooperative effort. The working group also verified that this signal satisfies all compatibility requirements and recommends this signal for broadcast by both the Galileo and GPS constellations.”^{5/}

U.S. and the EU Announce the Final Design for the GPS-Galileo Common Signal

“On 26 July 2007, the United States and the European Union announced their agreement to jointly adopt and provide an improved design for their respective Global Navigation Satellite System (GNSS) signals. These signals will be implemented on the Galileo Open Service and the GPS IIIA new civil signal.

Building on the historic cooperative agreement on GPS and Galileo signed between the two parties in June 2004, a joint compatibility and interoperability working group overcame technical challenges to design interoperable optimized civil signals that will also protect common security interests. The resulting GPS L1C signal and Galileo L1F signal have been optimized to use a multiplexed binary offset carrier (MBOC) waveform.”^{6/}

First Plenary Meeting on GPS and Galileo Cooperation by Representatives of the U.S., the European Community and Its Member States

“Representatives of the United States, the European Community and its Member States met in their first plenary session to review and discuss matters of mutual importance regarding cooperation in the use of global navigation satellite systems. Such consultations are held pursuant to the 2004 Agreement on the Promotion, Provision and Use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications between the United States of America and the EC and its Member States. During the meeting, representatives of the parties

^{4/} Bruce DeCleene, *GPS and Galileo Integration*, GPS.GOV, (Sept. 7, 2006), www.gps.gov/multimedia/presentations/2006/2006-09-CSIS/decleene.ppt.

^{5/} *Joint Statement on Galileo and GPS Signal Optimization By the European Commission (EC) and the United States (US)*, GPS.GOV (Mar. 24, 2006), <http://www.gps.gov/policy/cooperation/europe/2006/joint-statement/>.

^{6/} *United States and the European Union Announce Final Design for GPS-Galileo Common Civil Signal*, GPS.GOV (July 27, 2007), <http://www.gps.gov/policy/cooperation/europe/2007/MBOC-agreement/>.

reviewed the ongoing work of the U.S./EC working groups on GPS and Galileo technical and trade issues and discussed various issues related to the emergence of global and regional satellite navigation systems in addition to GPS and Galileo.

The Parties reaffirmed their commitment to the implementation of the Agreement and presented the current status of their respective systems. The U.S. intends to continue to operate GPS, a dual use system that provides precision timing, navigation and position location for civil and military purposes, and to provide the Standard Positioning Service for peaceful civil, commercial and scientific use on a continuous, worldwide basis, free of direct user fees. The European Community has launched the procurement of the Galileo system and revised the governance of the European GNSS Systems (Galileo and EGNOS) which will provide services including open, safety-of-life, commercial, and public regulated services. The Parties believe that compatibility and civil interoperability not only between GPS and Galileo, but also with other global navigation satellite systems, will promote global economic growth and strengthen transatlantic cooperation.

The Working Groups established under the Agreement provided updates on their ongoing activities and ideas for future work.”^{7/}

Joint Statement from the First Plenary Meeting on GPS-Galileo Cooperation

“The increased number of civil navigation signals available for space-based PNT will enhance not only the service robustness and availability, but will also potentially improve the service accuracy for mass-market users. Indeed, the probability of favorable satellite geometries is expected to improve as a result of the combination of both systems. Moreover, new safety of life applications will be enabled by the combined processing of GPS and Galileo signals. With the dual constellation, the computation of receiver autonomous integrity monitoring (RAIM) can be improved. As soon as the number of operational Galileo satellites becomes significant, the availability of RAIM will be boosted, thus enabling the ability of self-detection and isolation of faulty signals at any time and any place. The European Union and the United States are also cooperating to ensure that manufacturers around the world can build dual system civil receivers, capable of using GPS and Galileo. The parties understand that robust, market-based competition within the private sector has been the key to the current success of global satellite navigation system technology. The United States and the European Union are cooperating at the government level to promote continued competition among commercial companies.”^{8/}

International Committee on GNSS

“The International Committee on Global Navigation Satellite Systems (ICG), established in 2005 under the umbrella of the United Nations, promotes voluntary cooperation on matters of mutual interest related to civil satellite-based positioning, navigation, timing, and value-added services.

^{7/} *Joint Statement on GPS and Galileo Cooperation*, GPS.GOV (Oct. 23, 2008), <http://www.gps.gov/policy/cooperation/europe/2008/joint-statement/>.

^{8/} *GPS and Galileo Through Partnership*, U.S. DEP’T OF STATE, <https://2001-2009.state.gov/documents/organization/81594.pdf> (last visited Feb. 18, 2017).

The ICG contributes to the sustainable development of the world. Among the core missions of the ICG are to encourage coordination among providers of global navigation satellite systems (GNSS), regional systems, and augmentations in order to ensure greater compatibility, interoperability, and transparency, and to promote the introduction and utilization of these services and their future enhancements, including in developing countries, through assistance, if necessary, with the integration into their infrastructures. The ICG also serves to assist GNSS users with their development plans and applications, by encouraging coordination and serving as a focal point for information exchange.”^{9/} The U.S. and several European countries are members of the ICG.

^{9/} *International Committee on Global Navigation Satellite Systems (ICG)*, U.N. OFF. FOR OUTER SPACE AFF., <http://www.unoosa.org/oosa/en/ourwork/icg/icg.html> (last visited Feb. 18, 2017).